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ABSTRACT

Reported are the results of a correlational study designed to investigate sex differences in various correlates of attitude and achievement in mathematics. Biographical inventories consisting of 90 or 97 true-false statements were constructed to assess mathematical attitude. The inventories were administered to eighth grade, college freshmen, and graduate student groups. Other measures of ability and achievement were used with the analysis of the eighth grade students. Results of chi square analyses of independence between the measure of mathematics attitude and each of the inventory items are reported separately by sex for each student group. General scholastic ability is shown to be an important correlate of interest and ability in mathematics, and it is suggested that parental interests are also significant. The findings also indicate great complexity of factors governing ability and interest in mathematics. (RS)

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SEX DIFFERENCES IN ATTITUDE AND ACHIEVEMENT IN MATHEMATICS

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Review of Literature and Theories

Although sex differences in mathematical abilities have been found as early as the kindergarten level (Heimgartner, 1969; Madden, 1966), maturation and instruction certainly sharpen these differences. The popular conception is that mathematics is more of a masculine enterprise, but the results of certain studies (Meyer & Bendig, 1961; Cleveland & Bosworth, 1967) demonstrate that boys are not necessarily superior to girls in mathematics achievement, especially in elementary and junior high school. For example, Wozencraft (1963) reported that his samples of third and sixth grade girls were superior to the boys in both arithmetic reasoning and arithmetic fundamentals. Evidence from other investigations (Jarvis, 1964; Muscio, 1962; Very, 1967) indicates that boys are somewhat superior to girls in arithmetic reasoning but that girls are superior to boys in arithmetic fundamentals in grade six and beyond. The weight of the evidence points, however, to greater interest and achievement in mathematics by males in high school and college. Thus, Husén (1967) reported that the mathematics achievement of males was higher than that of females in the secondary schools of all 12 countries that he studied.

In any event, both sex differences and intra-individual differences in mathematical abilities appear to be smaller in elementary and junior high school than in high school and college. The findings of Very (1967) and Dye and Very (1968) provide

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support for the "Age Differentiation Hypothesis" that the factor structure of mathematical ability becomes more differentiated with maturity. Also, high school and college males reveal a greater number and more sharply differentiated factors than females, especially in the reasoning and spatial areas, whereas females are superior to males in verbal ability.

The observation that the abilities of both boys and girls become more differentiated as the individual passes through the school grades and has a greater variety of experiences is consistent with Ferguson's (1956) hypothesis that particular abilities result from transfer of training among different tasks required of people in a given culture. Thus, the emphasis in our culture on the acquisition by girls of relatively greater verbal skills, as opposed to quantitative reasoning and spatio-perceptual skills, may explain in part why a well-differentiated verbal factor but less distinct quantitative reasoning and spatial factors are obtained when a variety of psychological tests are administered to females.

Nature-Nurture Controversy

Many investigators have maintained that the differences between males and females in mathematical interests and achievements are produced by "differential cultural reinforcement." Thus, Husén (1967) concluded that sex differences in mathematics achievement are probably due to cultural rather than innate factors. And Very (1967) interpreted the greater sharpness of mathematical ability factors in males to the greater exposure of males, in contrast to females, to mathematics and related

areas in high school and college. However, Stafford (1963) hypothesized that sex differences in spatial and numerical abilities are transmitted by sex-linked, recessive (X chromosome) genes. Reported findings that mother-son and father-daughter correlations on measures of these abilities are equal to each other but higher than the mother-daughter correlation, and that the father=son correlation is essentially zero has been cited as supporting this hypothesis. Summarizing the reported data on this topic, Garron (1970) concluded that the sex chromosome complement and related sex differences in biochemical processes may underlie sex differences in spatial and numerical abilities, but the proof that he offers is not substantial.

Masculinity-Femininity of Interest

The hypothesis that interest in mathematics is a function of "masculine identification" was proposed some years ago by Plank and Plank (1954). This psychoanalytic hypothesis holds that aggression is necessary for mathematical activity and that women who like mathematics identify with a strong male figure.

In a test of the masculine identification hypothesis at the college level, Carlsmith (1964) obtained students' reports on the length of time that their fathers had been absent from the home when the students were children. These time reports were compared with the students' scores on the Verbal and Mathematical sections of the Scholastic Aptitude Test (SAT) and with the difference between SAT-Verbal and SAT-Mathematical scores. It was found that, for both boys and girls, the longer that the father was absent from the child during early childhood, the lower

was the latter's math score relative to his verbal score. In interpreting these findings, Carlsmith maintained that the masculine conceptual approach, which is necessary to achieve in mathematics, is acquired through a close and harmonious association with the father.

Other evidence for the importance of masculine role was obtained in a study by Elton and Rose (1967). Discriminant analysis of scores on the Omnibus Personality Inventory revealed that college girls classified as high in English and average in math, according to their scores on the American College Test, were more interested in cultural and artistic (i.e., more feminine) matters. On the other hand, girls classified as average in English and high in math had higher theoretical and lower esthetic (i.e., more masculine) interests. The hypothesis that relatively higher achievement in math than in English is associated with a more masculine interest pattern, and vice versa, was confirmed in a comparison of girls who were low in English and average in math with girls who were average in English and low in math. The investigators also cross-validated the results and concluded that "masculine role" is the most important predictor of English-math ability differences.

Personal Research

My own research on sex differences in mathematical abilities has been conducted in the broad context of studies concerning affective correlates of mathematics achievement (Aiken, 1970a). In a recent survey of the literature on attitudes toward mathematics (Aiken, 1970b), I suggested that multivariable

investigations of several different groups should be conducted and the results analyzed separately by age and sex. It is felt that only in this way can insight be obtained into the complex of interacting factors that affect mathematics achievement. Although a broadly-based project of the sort outlined in Table 1 (p. 13) would certainly yield a great deal of information on the problem, the following correlational study was carried out as a preliminary step to more carefully controlled multivariate investigations.

Method

Biographical Inventories. Statements concerning various correlates and determinants of mathematical attitudes and abilities were written to provide measures of these variables. From these items and six items designed to assess attitude toward mathematics (see Table 2, p. 14), three biographical inventories consisting of 90-97 true-false statements were constructed.

Subjects and Procedure. The 90-item inventory was administered to 124 graduate students in education (71 females and 53 males) at the University of Illinois in August, 1970. The majority of these students were public school teachers enrolled in summer courses and working toward graduate degrees in various areas of education; their median age was approximately 25 years. One of the 97-item inventories was administered to 182 eighth graders (85 girls and 97 boys) in a Greensboro, N.C. public school, and the other 97-item inventory to 225 entering freshmen (125 females and 100 males) at Guilford College in September, 1970. The median

ages of these two groups were approximately 13 years and 18 years. Thus, the three groups of students represented three age-educational levels 5-7 years apart on the average. For the eighth graders, seventh grade mathematics averages, ratings by seventh grade teachers, scores on the California Achievement Tests—Arithmetic Reasoning and Arithmetic Fundamentals, and California Test of Mental Maturity—Total IQs were also available.

Results of Analyses of Biographical Inventories

Chi square analyses of independence between the measure of mathematics attitude and each of the 84-91 true-false items were performed separately by sex for the eighth grade, college freshmen, and graduate student groups. In addition, for the eighth grade group, seventh-grade mathematics averages, seventh-grade teachers' ratings, CAT-Arithmetic Reasoning, CAT-Arithmetic Fundamentals, and CTMM-Total IQs were compared with responses to each of the inventory items (by chi square analyses), separately by sex. Also, for the eighth grade group, the means, intercorrelations, and selected multiple correlations for five variables are given in Table 6. Although the inventory items were actually arranged in random order for purposes of administration, statistically significant items are grouped according to content in Tables 3 and 4.

Inspection of the items in Category A of Tables 3 and 4 (pp. 15-23) shows that, for both boys and girls, the measure of attitude toward mathematics is closely related to interest in mathematics in general as well as routine computations, mathematical symbols and terms, and word problems.

There are several interesting sex differences in responses to the items in Category B. Eighth grade girls with high positive atttitudes toward mathematics report less interest in science; girls with high 7th grade math marks report less interest in scientific hobbies, and girls with high CAT-Arithmetic Reasoning scores report greater liking for working with ideas than real things. In contrast, eighth grade boys having positive attitudes toward mathematics report less interest in language arts, social studies, art, and music; boys with higher 7th grade math marks and higher CAT-Arithmetic Fundamentals scores report less interest in English than in other school subjects. This greater dislike by male mathemaphiles for literature, music, and art also applies to the college freshmen, but with the graduate students it is the female mathemaphiles who dislike the humanities and arts.

The items in Category C were written to study the relationship of mathematical interest and ability to language ability. A tentative conclusion from the eighth grade data is that high mathematical ability is associated with high linguistic interest and ability, and there are no important sex differences in this regard. But in the college freshman group positive attitude toward mathematics is associated with reportedly lower linguistic interest and ability.

Concerning the "personality" items in Category D, for the eighth grade girls low math ability is associated with "nervousness" or "anxiety," whereas reported "impatience" in boys is associated with high math ability. Furthermore, in contrast to

what might be predicted from the "masculine identification" hypothesis, eighth grade girls who are high in math ability do not view themselves as "tomboys" and do not wish they were boys. With respect to the matter of obedience to teachers and parents, both eighth grade boys of high math ability and college freshman males with positive math attitudes do not subscribe to obedience as much as their counterparts with lower scores on these variables. Furthermore, reported perseverance in eighth grade girls and graduate student women is related to high math ability. There are also differences among age and sex groups in the relationship between reported self confidence and math ability and attitude.

From the responses to the items in Category E it can be seen that, in general, reported achievement in arithmetic and mathematics is positively related to objective measures of math attitude and ability. The only important sex difference noted in this category concerns the first two items for the eighth graders. From the responses to these two items, it appears that boys who make higher grades in arithmetic than in other school subjects tend to like the subject, whereas girls whose grades in arithmetic are about the same as their grades in other school subjects tend to like it. Also, the responses to items in Category F indicate that, for both sexes, math attitude and ability are positively related to high grades in other school subjects as well.

The responses to items in Category G demonstrate that students with positive attitudes and high ability in mathematics tend to perceive their mathematics teachers more positively than students with negative attitudes and low ability in the subject.

Of course, it is not possible to determine the direction of cause and effect from these data.

Responses to items in Category H suggest a moderate relationship between sibling position and math attitude and ability, the first-born child scoring higher. This appears to be true for both sexes, but more significantly in the case of the male. The responses to the items in Categories I and J show that level of education and mathematical ability and interest in parents are positively related to the child's attitude and ability. There is a tendency for the boy's attitude and ability to be more closely related to those reported for the father, and the girl's attitude and ability to be more closely related to those reported for the mother. Finally, the item in Category K (eighth graders) is another experience variable associated with mathemaphilia.

Other Analyses of Eighth Grade Data

The results of further statistical analyses of the data for the eighth graders are presented in Tables 5 and 6. Table 5 (p. 24) shows that, in the case of girls, 7th grade teachers' ratings on "Courtesy, Industriousness, Leadership, Maturity, and Personal Appearance" are positively related to math attitude, and all ten rating variables are highly related to the three measures of mathematics achievement. For boys, however, only the rating on "Initiative" is related to attitude toward mathematics, but the majority of the rating variables are related to mathematics achievement.

The statistics in Table 6 (p. 25) lead to the following

conclusions: (1) Eighth grade girls scored significantly higher than boys on seventh grade final mathematics marks and on CAT-Arithmetic Fundamentals;[1] (2) CTMM-Total IQs are highly related to mathematics achievement for both sexes, girls' IQs being more highly related to achievement test scores and boys' IQs to mathematics grades; (3) Math attitude scores slightly improve the prediction of mathematics achievement from IQ scores in boys, but make no contribution to the prediction of girls' achievement.

Conclusions

The summaries presented in Tables 3, 4, 5, and 6 are the factual conclusions of this investigation. Considering these results as a whole, and those for the eighth graders in particular, it is clear that general scholastic ability (viz., intelligence) is an important correlate of interest and ability in mathematics. Furthermore, the results suggest that parental interests and abilities, and especially those of the father in the case of the boy and those of the mother in the case of the girl, are also significant. In addition, ordinal position of the child in the family, abilities and methods of mathematics teachers, and certain temperament variables such as anxiety and perseverance appear to play a role in determining math ability and interest. Finally, although this investigation was not a direct test of any specific

[1] On the measure of attitudes toward mathematics, the difference between the means of males and females was not significant in either the eighth grade or graduate student groups. For the college freshmen, however, the mean attitude score of males was significantly higher than that of females.

hypothesis--genetic, masculine identification, or differential cultural reinforcement--these findings point to the complexity of factors governing ability and interest in mathematics and the fruitlessness of searching for single causes.

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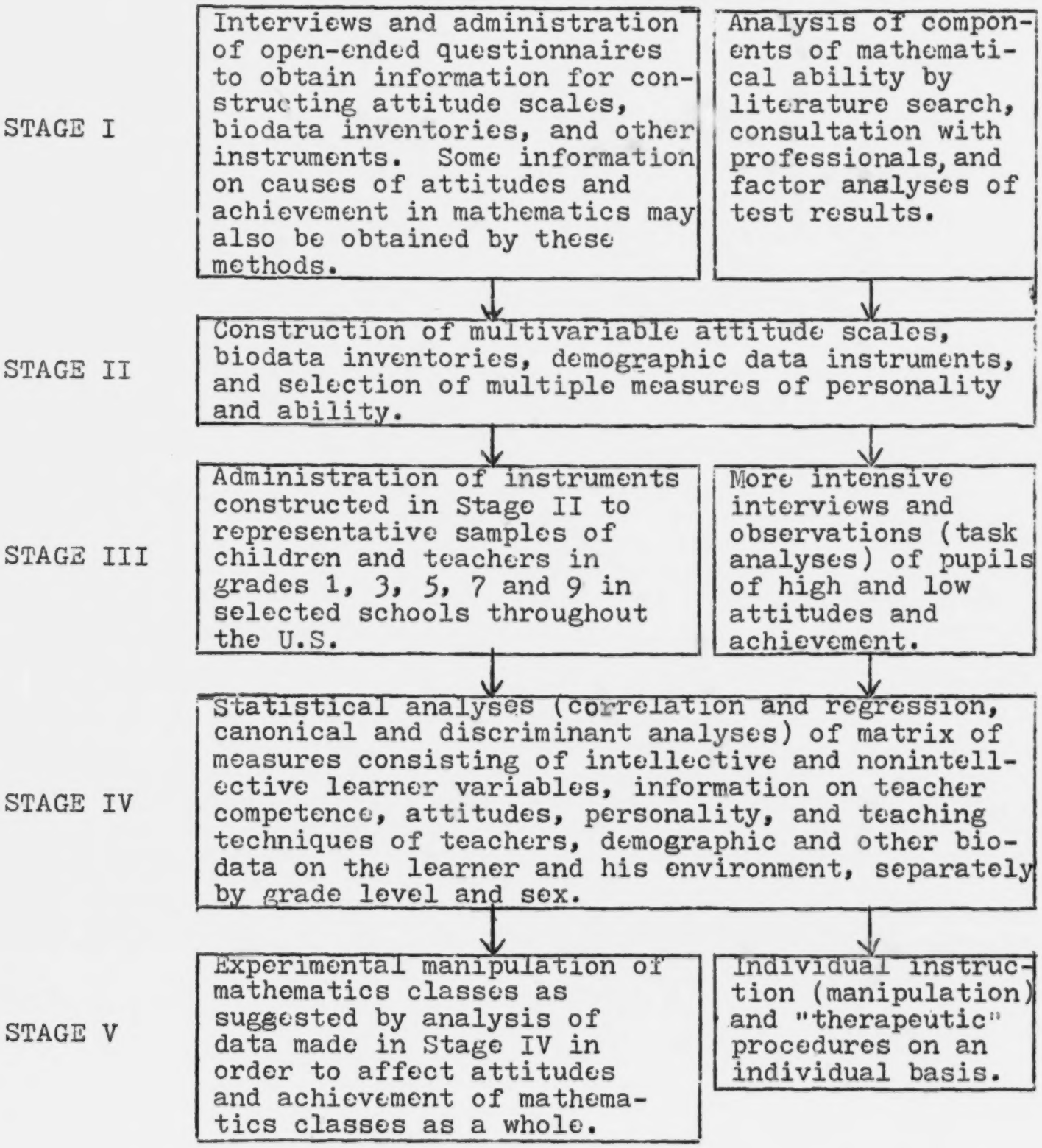
Table 1

Diagram of Proposed Research on Affective Factors in Mathematics Learning


STAGE I
Interviews and administration of open-ended questionnaires to obtain information for constructing attitude scales, biodata inventories, and other instruments. Some information on causes of attitudes and achievement in mathematics may also be obtained by these methods.
Analysis of components of mathematical ability by literature search, consultation with professionals, and factor analyses of test results.
STAGE II
Construction of multivariable attitude scales, biodata inventories, demographic data instruments, and selection of multiple measures of personality and ability.
STAGE III
Administration of instruments constructed in Stage II to representative samples of children and teachers in grades 1, 3, 5, 7 and 9 in selected schools throughout the U.S.
More intensive interviews and observations (task analyses) of pupils of high and low attitudes and achievement.
STAGE IV
Statistical analyses (correlation and regression, canonical and discriminant analyses) of matrix of measures consisting of intellective and nonintellective learner variables, information on teacher competence, attitudes, personality, and teaching techniques of teachers, demographic and other biodata on the learner and his environment, separately by grade level and sex.
STAGE V
Experimental manipulation of mathematics classes as suggested by analysis of data made in Stage IV in order to affect attitudes and achievement of mathematics classes as a whole.
Individual instruction (manipulation) and "therapeutic" procedures on an individual basis.

After Aiken (1970c), p. 253.

Table 2

Mathematics Attitude Items

I have never liked mathematics, and it is my most dreaded subject.
Mathematics is fascinating and fun.
Mathematics is a course in school that I have always enjoyed studying.
My mind goes blank, and I am unable to think clearly when working mathematics.
Mathematics is very interesting to me, and I have usually enjoyed mathematics and arithmetic classes.
Mathematics makes me feel uncomfortable, restless, irritable and impatient.

Table 3

Items on Biographical Inventory for Eighth Grade Group Significantly[a] Related to Mathematics Attitude and/or Achievement (N=182)[b]

Item Cat	Statement	Sex	Answer Given Sigificantly More Often by High Scorers Than Low Scorers on: Math Att Scale	7th Grade Math Mark	CAT Arith Reas Test	CAT Arith Fund Test
A	I am more interested in mathematics than in most other school subjects.	Girls Boys	T T			
A	I like to add, subtract, multiply, and divide.	Girls Boys	T T			
A	I have trouble with the terms and symbols used in mathematics.	Girls Boys	F F		F	F F
A	I have always had difficulty with word problems in arithmetic and mathematics.	Girls Boys	F F	F F	F F	F
B	I like to try to solve all kinds of puzzles and problems.	Girls Boys	T T			
B	I like to work with real things rather than ideas.	Girls Boys			F	
B	I have enjoyed scientific activities as a hobby.	Girls Boys		F		
B	I am more interested in science than in other school subjects.	Girls Boys	F			
B	I am more interested in English than in other school subjects.	Girls Boys		F	F F	F

(Cont'd on next page)

Table 3 (cont'd)

	I am more interested in language arts and social studies than in other school subjects.	Girls Boys	F			
	I am more interested in music and art than in science and other technical subjects.	Girls Boys		F		
	My parents talked "baby talk" to me a lot when I was a small child.	Girls Boys		F	F F	F F
	I have always had trouble saying exactly what I mean when talking to other people.	Girls Boys			F	F
C	I have always had trouble expressing my thoughts in writing.	Girls Boys			F	
	I am a rather nervous person	Girls Boys		F	F	F
	Sometimes I get very nervous when I try to study.	Girls Boys		F		F
	I find it difficult to sit still for a long period of time.	Girls Boys		F		F
D	I frequently get impatient with people or things.	Girls Boys		T	T	
	I usually work slowly and carefully rather than quickly.	Girls Boys		F		
	I a a girl who is something of a "tomboy"	Girls		F	F	F

(Cont'd on next page)

Table 3 (cont'd)

	I have sometimes wished that I were a member of the opposite sex.	Girls Boys			F	
	I have always obeyed the rules and regulations in school.	Girls Boys			F	
	I usually stick to a job until it is finished.	Girls Boys	T			
	I have a great deal of confidence in my ability to succeed in whatever I want to do.	Girls Boys		F		
	In elementary school, my grades in arithmetic were usually high.	Girls Boys	T	T		
	My grades in arithmetic and mathematics have usually been about the same as my grades in other school subjects.	Girls Boys		T	T	T
E	My grades in arithmetic and mathematics have usually been lower than my grades in other school subjects.	Girls Boys	F F	F F	F F	F F
	I have usually made higher grades in arithmetic and mathematics than in most other school subjects.	Girls Boys	T T			
	Almost all of my marks in the seventh grade were A's and B's.	Girls Boys	T	T T	T T	T T
F	I have usually been an excellent student in school.	Girls Boys			T T	T

(Cont'd on next page)

Table 3 (cont'd)

G	My mathematics teachers in school have usually been somewhat impatient and demanding.	Girls Boys	F F	F	F F	F
	Some of my very best teachers have taught arithmetic and mathematics.	Girls Boys	T			
	Almost everyone in my family likes mathematics.	Girls Boys	T T			
	I have an older brother who likes mathematics.	Girls Boys		F		
H	I have an older brother.	Girls Boys			F	
	I am the youngest child, but not the only child, in our family.	Girls Boys		F		
	I am the oldest child, but not the only child, in our family.	Girls Boys		T		
	My father likes mathematics.	Girls Boys	T			
	My father made high grades in mathematics when he was in school.	Girls Boys	T			
	My father uses mathematics on his job.	Girls Boys	T			
I	My father graduated from high school.	Girls Boys		T	T T	
	My father attended college.	Girls Boys				T

(Cont'd on next page)

Table 3 (cont'd)

	My father attended graduate school.	Girls Boys				T
	My father is a professional man (doctor, lawyer, engineer, teacher. etc.)	Girls Boys	T	T	T	T
	When I was younger, my father was away from home for one or more periods of several weeks or longer.	Girls Boys				F F
J	My mother likes mathematics.	Girls Boys	T			
	My mother made high grades in mathematics when she was in school.	Girls Boys	T			
	My mother graduated from high school.	Girls Boys	T	T	T T	T
	My mother attended college.	Girls Boys			T	T
K	I have traveled a lot and visited many places.	Girls Boys	T T			

[a] At or beyond the .05 level by chi squared tests.

[b] 85 girls and 97 boys.

Table 4

Items on Biographical Inventories for College Freshmen and Graduate Students Significantly Related[a] to Attitude Toward Mathematics

Item Cat.	Statement	Sex	Answer Given Significantly More Often by High Scorers Than by Low Scorers on Math Attitude Scale	
			College Freshmen (125 females, 100 males)	Graduate Students (71 females, 53 males)
A	I am more interested in mathematics than in most other school subjects.	Fe Ma	T T	
	In school or college I took mathematics courses that were not required.	Fe Ma	T T	T T
	I enjoy doing routine numerical computations.	Fe Ma	T T	T
	I have particular difficulty with the terms and symbols used in mathematics.	Fe Ma	T F	
	I have always had difficulty with word problems involving mathematics.	Fe Ma	F F	F F
B	I like to do detailed work.	Fe Ma	T	T
	I like to try to solve difficult problems or puzzles.	Fe Ma		T T
	I like to write stories or papers.	Fe Ma	F F	
	I am more interested in literature, music, and art than in science and technology.	Fe Ma	F	F

(Cont'd on next page)

Table 4 (Cont'd)

	I am more interested in literature and/or art than in other school subjects.	Fe Ma	F F	
	I am more interested in the social sciences (sociology, history, political science, psychology, etc.) than in other school subjects.	Fe Ma	F F	
	I read faster than most people.	Fe Ma	F F	
	I do a lot of leisure reading on my own.	Fe Ma	F	
C	I have always had trouble expressing my thoughts in writing.	Fe Ma	T	
	Ihave always had trouble expressing my thoughts exactly in conversations.	Fe Ma	T T	
	Sometimes I become very nervous or anxious when I try to study.	Fe Ma	F	
	I believe that reason can solve most of the world's problems.	Fe Ma		T
D	Children should always be obedient toward their parents and teachers.	Fe Ma	F	
	When a task becomes difficult for me, I keep trying until it is completed.	Fe Ma		T
	I have a great deal of faith in my ability to succeed in my undertakings.	Fe Ma		T

(Con't on next page)

Table 4 (Cont'd)

	In elementary schools, my marks (grades) in arithmetic were usually very high.	Fe Ma	T	
	My elementary and high school marks (grades) in mathematics were about the same as my marks in other school subjects.	Fe Ma	T T	
	In high school, my grades in mathematics were A's and B's.	Fe Ma	T T	
E	My marks (grades) in mathematics were lower than my marks (grades) in other school subjects.	Fe Ma	F F	F F
	I made higher grades in arithmetic and mathematics than in most other school subjects.	Fe Ma	T T	
	On standardized tests of achievement or ability, I have always scored higher on the verbal (language) sections than on the quantitative (mathematical) sections.	Fe Ma	F F	F F
	Almost all of my marks in high school were A's and B's.	Fe Ma	T T	T T
F	I have usually been an excellent student in school.	Fe Ma		T T
	My mathematics teachers in school were impatient and demanding.	Fe Ma	F	
G	Some of my very best teachers taught mathematics.	Fe Ma	T T	

(Cont'd on next page)

Table 4 (Cont'd)

	My mathematics teachers have been rather poor instructors.	Fe Ma	F F	
H	My attitudes and interests are quite different from those of either of my parents.	Fe Ma	T	
	I was the first-born, but not the only, child in our family.	Fe Ma	F	
J	My mother likes (liked) mathematics.	Fe Ma	T	
K	When I was growing up, we lived in a rural area for most of the time.	Fe Ma		T

[a]At or beyond the .05 level by chi squared tests.

Table 5

Comparison of Ratings by Teachers With Mathematics Attitude and Achievement in Eighth Grade Students (N=181)

Rating Variable	Sex	Statistical Significance[a] of Positive Relationship Between Ratings and Scores on			
		Math Att Scale	7th Grade Math	CAT Arith Fund Test	CAT Arith Reas Test
Cooperation	Girls	n.s.	.001	.001	.001
	Boys	n.s.	.001	.001	.001
Courtesy	Girls	.01	.001	.001	.001
	Boys	n.s.	n.s.	.005	.001
Dependability	Girls	n.s.	.001	.001	.001
	Boys	n.s.	.001	n.s.	.001
Industriousness	Girls	.05	.001	.001	.001
	Boys	n.s.	.001	.001	.001
Initiative	Girls	n.s.	.001	.001	.001
	Boys	.05	.001	.001	.001
Leadership	Girls	.01	.001	.001	.001
	Boys	n.s.	.001	.001	.001
Maturity	Girls	.025	.001	.001	.001
	Boys	n.s.	.001	.005	.005
Personal Appearance	Girls	.001	.001	.001	.001
	Boys	n.s.	n.s.	.05	n.s.
Self Control	Girls	n.s.	.001	.001	.001
	Boys	n.s.	.005	.005	.02
Reading Interest	Girls	n.s.	.001	.001	.001
	Boys	n.s.	.001	.001	.001

[a] By chi squared tests.

Table 6

Correlations of Math Attitude Scores and CTMM Total IQs

With Mathematics Grades and Achievement Test Scores

Variable	Girls				Boys			
	Mean	$r_{1.}$	$r_{2.}$	R^a	Mean	$r_{1.}$	$r_{2.}$	R^a
1. Math Attitude Scale	3.58				3.27			
2. California Test of Mental Maturity-Total I.Q.	108.80	.36			104.07	.13		
3. California Achievement Tests-Arithmetic Fundamentals	43.91[b]	.30	.71	.71	32.93[b]	.29	.62	.65
4. California Achievement Tests-Arithmetic Reasoning	56.70	.29	.83	.83	55.62	.36	.69	.74
5. Seventh Grade Final Mathematics Average	2.85[c]	.33	.60	.61	2.32[c]	.36	.67	.72

[a]Multiple correlation coefficients, using Math Attitude Scale scores and CTMM-Total IQs as predictor variables.

[b]The mean for girls on CAT-Arithmetic Fundamentals is significantly higher than the mean for boys ($t = 2.66$, $p = .01$).

[c]The mean for girls on seventh grade math average is higher than the mean for boys. ($t = 3.76$, $p = .01$)